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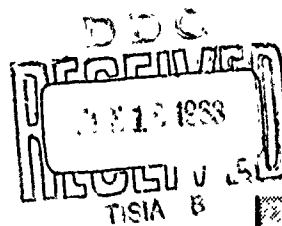


# A Method of Refining Electrical Refractive Index Profiles When Using Radiosonde Data

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MARCH 1963



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ABSTRACT

↓ A method is described for providing greater detail in the profile of electrical refractive index derived from radiosonde data. This method uses a greater number of significant levels of moisture. Profiles derived from radiosonde are compared with selected refractometer profiles. In addition, selected data are used to illustrate certain space and time variations of the refractive index in the Eglin Gulf Test Range. ↗

PUBLICATION REVIEW

*This technical documentary report has been reviewed and is approved.*



A. T. CULBERTSON  
Brigadier General, USAF  
Vice Commander

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# DEFINITION OF TERMS

|                 |   |
|-----------------|---|
| Circular P      | <u>Manual of Radiosonde Code</u> (see REFERENCES).  |
| Ducting Layer   | A layer of N in which $\frac{\Delta N}{\Delta h} > -48$ N units per 1000 ft.  |
| n               | Electrical index of refraction computed in the Weather Program 102 on the IBM 7094 using the equation<br><br>$n = 1 + \frac{77.6}{T} \left[ p + e \left( \frac{4830}{T} - \frac{11}{77.6} \right) \right] 10^{-6}$ <div>           where: p = pressure in millibars<br/>           T = temperature in degrees Kelvin<br/>           e = vapor pressure in millibars.         </div> |
| N               | A unit of the electrical index of refraction as given by the equation $N = (n-1)10^6$ .   |
| Radiosonde Data | For this report, radiosonde data are upper air sounding data made with a GMD-1A Rawin Set using the AMT-12 or AMT-4 instrument with a ML 476/AMT carbon humidity element.   |

## SECTION 1 - INTRODUCTION

Weather support for the Eglin Gulf Test Range (EGTR), Air Proving Ground Center (APGC), is provided by Detachment 10, 4th Weather Group, Eglin Air Force Base, Florida. In addition to the demand for conventional upper air data, there has been an increasing demand for index of refraction data in support of radar tracking and evaluation programs. To satisfy these demands in the most efficient manner, the radiosonde raw data are processed by an IBM 7094 computer utilizing the APGC Mathematical Services Laboratory Weather Program 102. The data are computed in various increments of height to suit the requirements of project mathematicians and ballisticians. The data are reduced to values for temperature, pressure, dew point, relative humidity, wind speed, wind direction, vapor pressure, air density, optical index of refraction, electrical index of refraction, and speed of sound.

In this report, a method is proposed for evaluating radiosonde recorder records to permit finer detail in electrical index of refraction profiles derived from the radiosonde.

## SECTION 2 - ELECTRICAL INDEX OF REFRACTION VARIATIONS

### FORMATION OF A DUCTING LAYER

Fig. 1 illustrates the formation of a ducting layer on 1 November 1962. In the N profile taken at 0500Z, there is an indication of a layer present at 4200 ft. This layer has a  $\frac{\Delta N}{\Delta h}$  value of -14 N units per 1000 ft. At 1100Z the same layer lowered, with the base occurring at 3550 ft and the top at 4750 ft. It will be noted that magnitude of the N gradient increased ( $\frac{\Delta N}{\Delta h} = -23$  N units per 1000 ft). At 1700Z the layer had intensified into a ducting layer based at 3950 ft and with its top at 4450 ft. The  $\frac{\Delta N}{\Delta h}$  value was now -59 N units per 1000 ft. At 2300Z the layer was still present, based at 4600 ft and topped at 5400 ft, but with lesser N gradient (the layer having a value of -41 N units per 1000 ft).

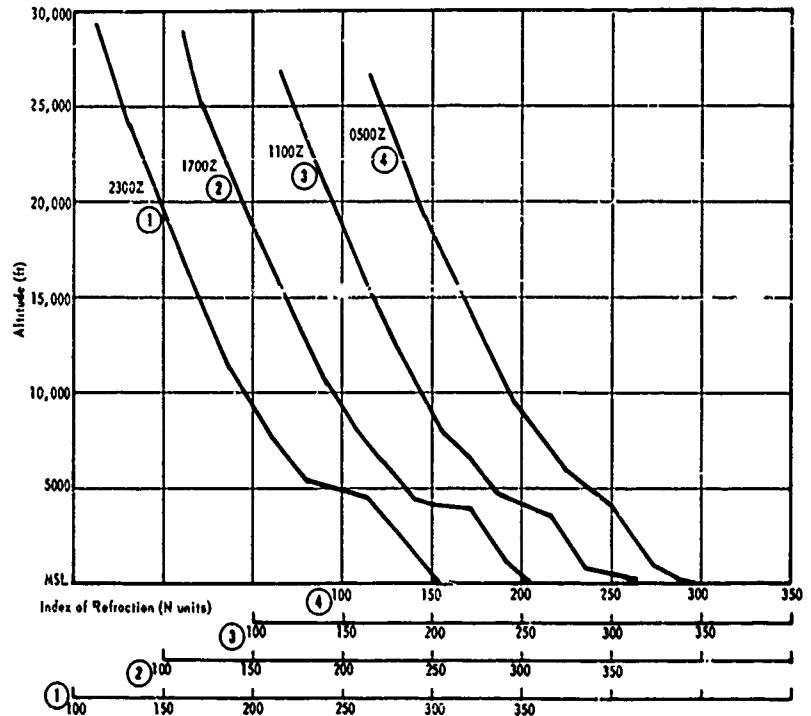


Fig. 1: Electrical Index of Refraction Profiles Showing Formation of a Ducting Layer, Eglin Main (Station 221), 1 November 1962.

#### VARIATIONS DUE TO GEOGRAPHICAL LOCATIONS OF RECORDING STATIONS

The change of  $N$  with distance is illustrated in Fig. 2. Fig. 2 is a plot of electrical index of refraction profiles taken at the same time (1700Z) but at different locations. Note the similarity between the profile for Eglin Main and for EGTR Site D-3, a station located approximately 80 statute miles southeast of Eglin Main. No evidence of a duct is present on these profiles, while the profile for Site D-7, located 370 statute miles southeast of Eglin Main, reveals a ducting layer present and based at 4500 ft. This is one example of the space variability of refractive profiles in the EGTR. Other similar data for late spring, summer, and fall 1962 were obtained by the Eglin weather station.

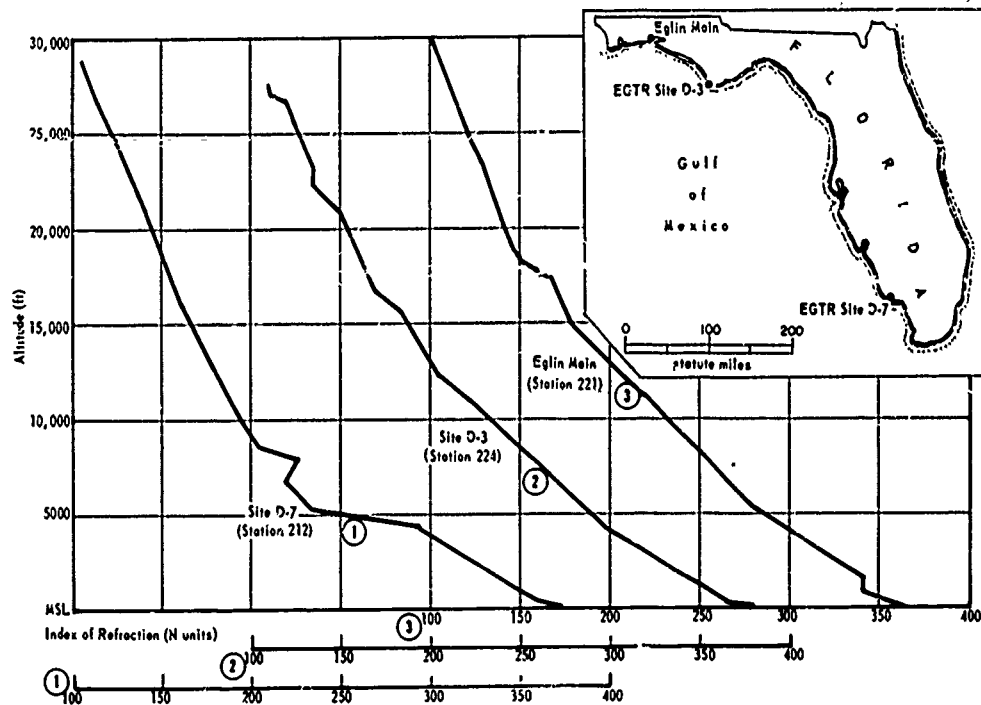


Fig. 2: Electrical Index of Refraction Profiles Recorded at 1700Z, 8 October 1962, at Three Stations.

#### COMPARISON OF RADIOSONDE AND REFRACTOMETER PROFILES

Since November 1962, an airborne refractometer has been used periodically in the Eglin Gulf Test Range area to obtain direct measurements of the electrical index of refraction during tests under APGC Project 8780V18. During these tests, an ASH-14 refractometer is mounted in C-131 aircraft.

A refractometer operates by drawing a steady flow of outside air through a sampling cavity as the aircraft ascends (or descends) in spirals. The microwave refractometer compares the electromagnetic

resonance of two geometrically similar cavities: one filled with reference atmosphere, the other with a sample of the atmosphere to be observed. Inasmuch as there is a direct proportion between the refractive index and the resonant frequency of a given cavity, the difference between the resonant frequencies of the two cavities is converted within the instrument to an N modulus in a straightforward manner.

As the ASH-14 retractometer soundings were made at approximately the same time and location as balloon-released radiosonde soundings, it is possible to compare samples of these soundings. Figs. 3 and 4 are two examples of these comparisons.

In comparing these soundings the following salient points are noted:

- a. The configuration of the profiles are generally in good agreement.
- b. Detail is smoothed out in the radiosonde profile.
- c. The elevated layers measured by the refractometer are often sharper and thinner than those recorded by the radiosonde.

One of the main contributing reasons for the relative smoothness of the radiosonde profiles is the scarcity of observation points. This scarcity of observation points is partially due to limitations of present radiosonde equipment, i. e., the sampling frequency of the instrument. It is aggravated by the present method of evaluating the radiosonde recorder record. Circular P lays out rigid requirements for the selection of points to be evaluated and reduced. These requirements are generally quite good; however, if more latitude were allowed the operator in the selection of radiosonde data points, a finer detail of the refractive profile would result.

### SECTION 3 - METHOD OF REFINING RADIOSONDE N PROFILES

An experiment was made to determine the effect on the computed N profile of using a different procedure for selecting significant points from the radiosonde recorder record. The Circular P method of determining significant moisture levels will be referred to as the 10-percent rule. Briefly, if a measured recorder division for moisture at a given level would result in a relative humidity which differs by at least 10 percent in relative humidity units from the linear approximation

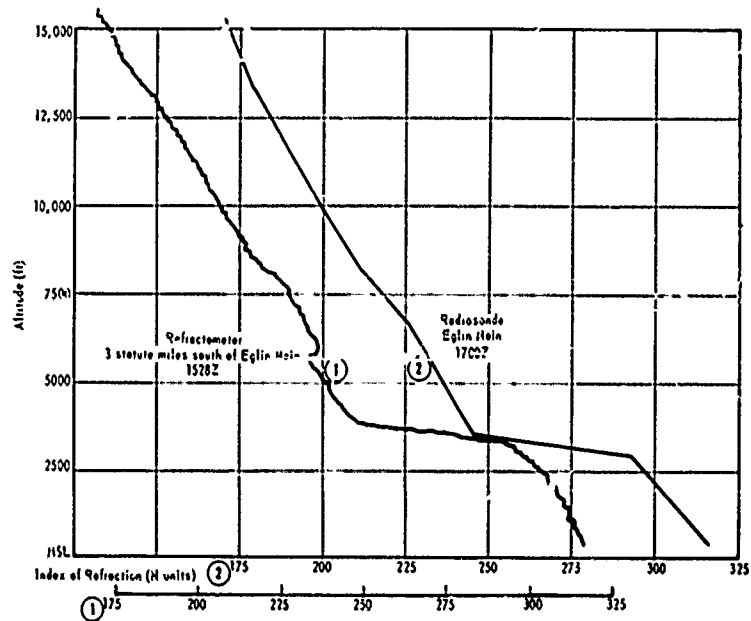


Fig. 3: Comparison of Electrical Index of Refraction Profiles Derived from Refractometer and Radiosonde Soundings, 15 November 1962.

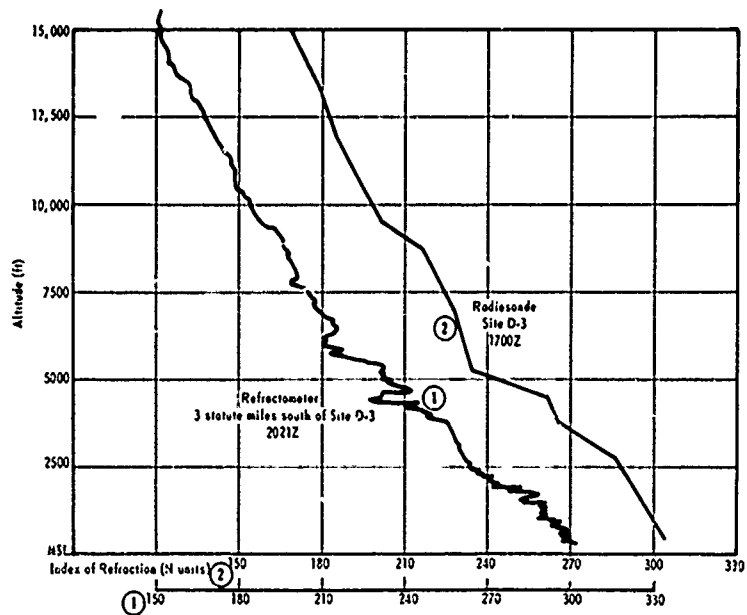


Fig. 4: Comparison of Electrical Index of Refraction Profiles Derived from Refractometer and Radiosonde Soundings, 5 November 1962.

for that level (determined from higher and lower measured values), it is considered significant. For example, if the measured recorder division of moisture at a given level results in a relative humidity of 48 percent and the linear approximation for that level is 40 percent, the relative humidity deviation is 8 percent and the given level is not considered significant by the 10 percent rule. Table 1 will serve to illustrate the effect of neglecting moisture deviations of less than 10 percent from the linear approximation at various temperatures. Temperatures as evaluated by Circular P were considered adequate for the proposed method because of the relative insensitivity of N to small changes in temperature.

TABLE 1. APPROXIMATE EFFECT OF HUMIDITY CHANGE ON VALUE OF N (700 - 1000mb).

| Temperature<br>(°C) | Δ Relative<br>Humidity<br>Change<br>(%) | Δ N<br>(N Units) |
|---------------------|---|------------------|
| 30                  | 10                                      | 18               |
| 20                  | 10                                      | 12               |
| 10                  | 10                                      | 6                |
| 0                   | 10                                      | 3                |

For the proposed method, a change in moisture which causes the N profile to deviate by 3 N units or more from a linear profile is considered significant. Using values from Table 1 to estimate the effect on the N unit profile of relative humidity deviations at specific temperatures, Fig. 5 was derived to portray graphically the relative humidity deviation at any temperature to produce a 3 N unit change. To determine significant points by this method, the following procedure is used:

a. With a psychrometric calculator CP-223A/UM, the humidity deviations and temperatures are computed for all points which deviate more than one humidity recorder division from the linear profile.

b. Using these computed temperatures and humidity deviations, the points which are considered significant can be determined from Fig. 5. Any point which falls within the unshaded area of Fig. 5 will have a value of 3 N units or greater and, therefore, is considered significant.

c. The last observed point on the linear profile below a point selected as significant by the above criteria is considered significant. Also, the first observed point below the point selected is considered significant (see Fig. 6).

Fig. 7 illustrates the N profiles determined for 1700Z, 26 October 1962. Case I is the profile prepared from data selected using the 10-percent rule; Case II is the profile prepared from data selected using the proposed method. Table 2 is a composite listing of data from the computer printouts from which Case I and Case II were plotted. The unasterisked data were common to both printouts, while the asterisked data were unique to Case II. When using the proposed method, all points computed for Case I were included with the asterisked data to provide finer detail.

Fig. 8 (Table 3) is analogous to Fig. 7, but for 15 October 1962 instead of 26 October 1962. Fig. 9 (Table 4) is similarly analogous to Fig. 10 (Table 5).

In Fig. 7, the addition of more observation points in Case II sharply defines the configuration of the moist layer between 5000 ft and 10,000 ft.

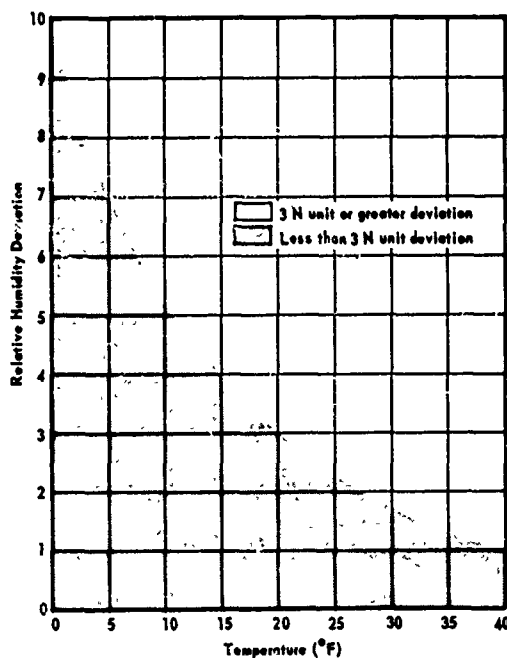


Fig. 5: Temperature Vs Relative Humidity Deviation to Produce a 3 N Unit Deviation.

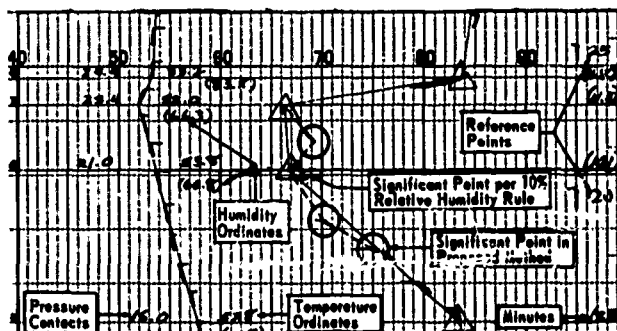


Fig. 6: Portion of Radiosonde Recorder Record, Eglin Main, 1700Z, 26 October 1962.

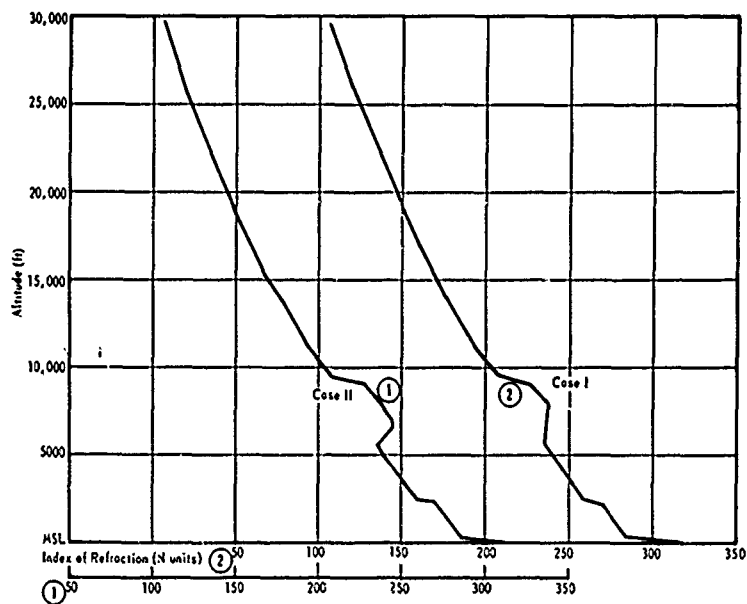


Fig. 7: Comparison of Electrical Index of Refraction Profiles Derived by the Proposed Method and by the 10-Percent Relative Humidity Rule, Eglin Main, 1700Z, 26 October 1962.

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TABLE 2. RADIOSONDE DATA AT THE SIGNIFICANT LEVELS,  
EGLIN MAIN, 1700Z, 26 OCTOBER 1962.

| p1     | G      | T    | D     | THETA | V   | RH  | NE       | NO       |
|--------|--------|------|-------|-------|-----|-----|----------|----------|
| 1026.0 | 66.    | 15.1 | 4.2   | 90.   | 10. | 48. | 1.000313 | 1.000260 |
| 1016.0 | 337.   | 13.5 | -14.2 | 78.   | 9.  | 13. | 1.000284 | 1.000279 |
| 946.0  | 2290.  | 5.7  | -14.0 | 13.   | 6.  | 16. | 1.000270 | 1.000264 |
| 938.0  | 2520.  | 9.7  | -43.7 | 5.    | 6.  | 1.  | 1.000258 | 1.000261 |
| *862.0 | 4812.  | 8.0  | -45.0 | 320.  | 18. | 1.  | 1.000238 | 1.000242 |
| 837.0  | 5607.  | 7.7  | -24.2 | 313.  | 19. | 8.  | 1.000235 | 1.000235 |
| *803.0 | 6721.  | 4.2  | -5.4  | 310.  | 21. | 49. | 1.000244 | 1.000248 |
| *790.0 | 7157.  | 3.3  | -4.0  | 313.  | 23. | 59. | 1.000244 | 1.000225 |
| 765.0  | 8011.  | 1.8  | -4.7  | 318.  | 27. | 62. | 1.000237 | 1.000219 |
| *752.0 | 8464.  | 0.7  | -6.4  | 320.  | 29. | 59. | 1.000237 | 1.000216 |
| 734.0  | 9102.  | -0.7 | -7.1  | 320.  | 32. | 62. | 1.000227 | 1.000212 |
| 722.0  | 9772.  | 1.4  | -17.7 | 317.  | 34. | 9.  | 1.000207 | 1.000208 |
| *694.0 | 10580. | 1.8  | -48.8 | 312.  | 35. | 1.  | 1.000196 | 1.000199 |
| *682.0 | 11041. | 1.7  | -48.9 | 307.  | 37. | 1.  | 1.000193 | 1.000196 |
| *658.0 | 11986. | 0.7  | -49.5 | 300.  | 37. | 1.  | 1.000187 | 1.000189 |
| *625.0 | 13335. | -1.7 | -36.3 | 298.  | 36. | 5.  | 1.000180 | 1.000182 |
| 610.0  | 13967. | -2.9 | -40.7 | 300.  | 36. | 1.  | 1.000176 | 1.000178 |
| 576.0  | 15455. | -4.0 | -52.4 | 301.  | 37. | 1.  | 1.000166 | 1.000169 |
| 565.0  | 15953. | -4.8 | -53.0 | 301.  | 38. | 1.  | 1.000164 | 1.000166 |

p1 is the atmospheric pressure in millibars.  
 G is the geopotential altitude in feet.  
 T is the atmospheric temperature in degrees centigrade.  
 D is the dew-point in degrees centigrade.  
 Theta is the direction from which the wind blew, in degrees from north.  
 V is the wind speed in knots.  
 RH is the relative humidity in percent.  
 NE is the electrical index of refraction of the atmosphere.  
 NO is the optical index of refraction of the atmosphere.

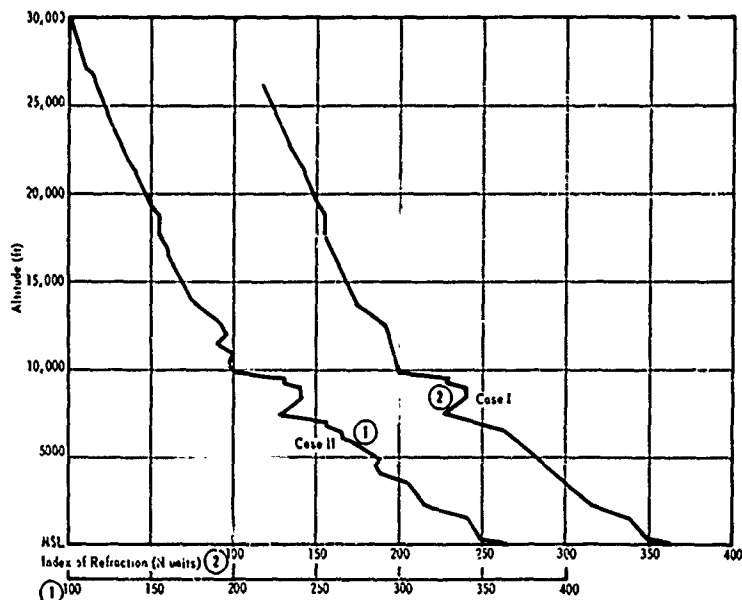


Fig. 8: Comparison of Electrical Index of Refraction Profiles Derived  
by the Proposed Method and by the 10-Percent Relative Humidity Rule,  
Eglin Main, 1700Z, 15 October 1962.

TABLE 3. RADIOSONDE DATA AT THE SIGNIFICANT LEVELS,  
EGLIN MAIN, 1700Z, 15 OCTOBER 1962.

| P <sup>1</sup> | G      | T    | D     | THETA | V   | RH  | NE       | NO       |
|----------------|--------|------|-------|-------|-----|-----|----------|----------|
| 1017.2         | 66.    | 29.1 | 21.5  | 110.  | 3.  | 64. | 1.000366 | 1.000263 |
| 1007.0         | 360.   | 25.9 | 18.3  | 117.  | 9.  | 63. | 1.000349 | 1.000263 |
| 967.0          | 1528.  | 22.6 | 17.9  | 111.  | 10. | 75. | 1.000341 | 1.000256 |
| *950.0         | 2035.  | 21.2 | 14.8  | 138.  | 8.  | 67. | 1.000322 | 1.000253 |
| 939.0          | 2367.  | 21.4 | 14.0  | 135.  | 7.  | 63. | 1.000316 | 1.000250 |
| *899.0         | 3602.  | 18.5 | 13.2  | 129.  | 7.  | 71. | 1.000305 | 1.000241 |
| *884.0         | 4075.  | 17.1 | 10.0  | 134.  | 8.  | 63. | 1.000290 | 1.000239 |
| *874.0         | 4394.  | 17.0 | 9.9   | 138.  | 9.  | 63. | 1.000287 | 1.000236 |
| *869.0         | 4555.  | 16.5 | 9.8   | 140.  | 9.  | 65. | 1.000286 | 1.000235 |
| *860.0         | 4846.  | 15.6 | 10.3  | 144.  | 10. | 71. | 1.000287 | 1.000234 |
| *828.0         | 5901.  | 13.8 | 6.8   | 147.  | 12. | 63. | 1.000269 | 1.000226 |
| *823.0         | 6069.  | 13.2 | 6.1   | 149.  | 12. | 62. | 1.000266 | 1.000226 |
| 808.0          | 6576.  | 12.1 | 6.9   | 152.  | 11. | 70. | 1.000265 | 1.000222 |
| *799.0         | 6884.  | 11.4 | 4.2   | 152.  | 10. | 61. | 1.000256 | 1.000221 |
| *794.0         | 7057.  | 11.3 | 4.4   | 152.  | 9.  | 62. | 1.000255 | 1.000219 |
| *782.0         | 7474.  | 11.1 | -9.6  | 154.  | 8.  | 22. | 1.000227 | 1.000217 |
| 756.0          | 8399.  | 9.9  | 2.0   | 149.  | 4.  | 58. | 1.000240 | 1.000210 |
| 735.0          | 9165.  | 7.7  | 3.0   | 127.  | 2.  | 72. | 1.000239 | 1.000206 |
| 729.0          | 9387.  | 7.0  | -1.1  | 120.  | 2.  | 56. | 1.000229 | 1.000205 |
| 725.0          | 9536.  | 7.3  | 0.2   | 115.  | 2.  | 61. | 1.000230 | 1.000203 |
| 724.0          | 9573.  | 7.4  | -4.9  | 114.  | 2.  | 41. | 1.000220 | 1.000203 |
| 717.0          | 9836.  | 8.5  | -30.3 | 110.  | 2.  | 4.  | 1.000200 | 1.000201 |
| 712.0          | 10026. | 8.9  | -44.4 | 110.  | 2.  | 1.  | 1.000196 | 1.000199 |
| *688.0         | 10954. | 7.6  | -17.4 | 109.  | 2.  | 15. | 1.000198 | 1.000193 |
| *672.0         | 11589. | 6.8  | -27.9 | 101.  | 2.  | 6.  | 1.000189 | 1.000189 |
| 660.0          | 12073. | 5.9  | -11.7 | 80.   | 1.  | 27. | 1.000195 | 1.000186 |
| *645.0         | 12690. | 4.6  | -12.4 | 31.   | 1.  | 28. | 1.000192 | 1.000183 |
| *615.0         | 13956. | 1.8  | -48.8 | 359.  | 3.  | 1.  | 1.000174 | 1.000176 |
| *555.0         | 16641. | -4.0 | -52.5 | 80.   | 2.  | 1.  | 1.000160 | 1.000163 |
| 548.0          | 16969. | -4.6 | -52.8 | 36.   | 2.  | 1.  | 1.000159 | 1.000161 |
| 533.0          | 17683. | -6.6 | -54.1 | 301.  | 0.  | 1.  | 1.000155 | 1.000158 |
| 510.0          | 18810. | -8.4 | -24.6 | 282.  | 2.  | 26. | 1.000154 | 1.000152 |

<sup>1</sup> See Table 2 for an explanation of terms and abbreviations used in this table.

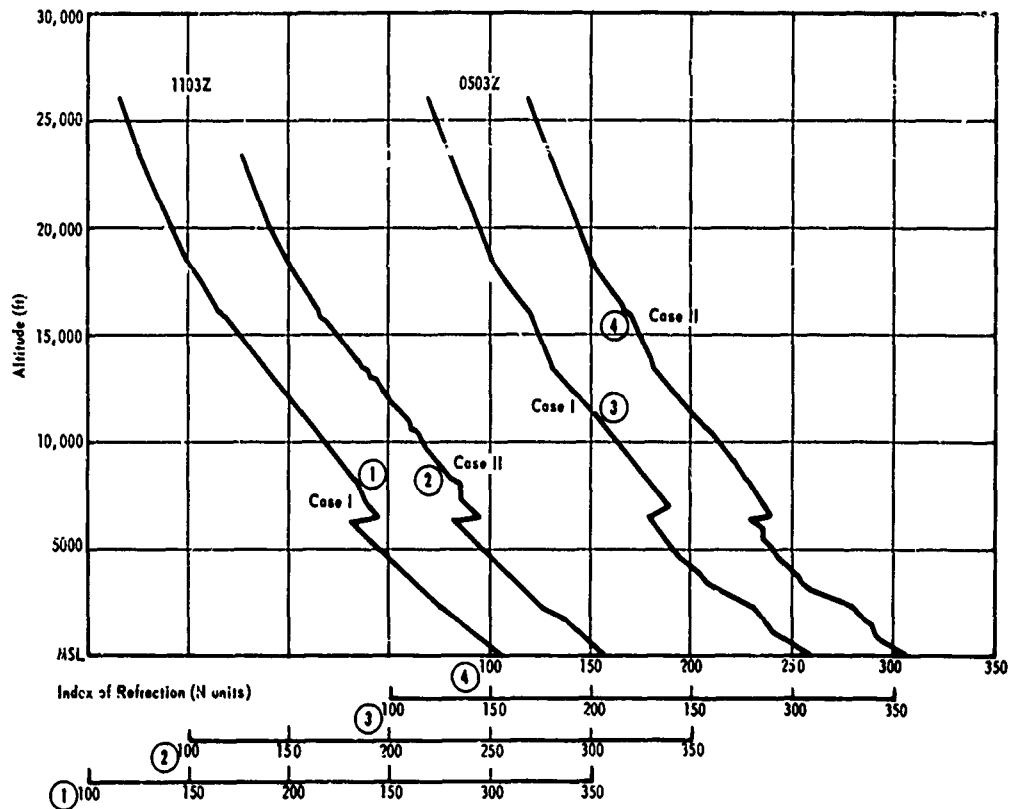


Fig. 9: Comparison of Electrical Index of Refraction Profiles Derived by the proposed Method and by the 10-Percent Relative Humidity Rule, Eglin Main, 0503Z and 1103Z, 13 February 1963.

TABLE 4. RADIOSONDE DATA AT THE SIGNIFICANT LEVELS,  
EGLIN MAIN, 0503Z, 13 FEBRUARY 1963.

| P <sup>1</sup> | G      | T     | D     | THETA | V   | RH  | NE       | NO       |
|----------------|--------|-------|-------|-------|-----|-----|----------|----------|
| 1013.0         | 66.    | 0.3   | -6.2  | 310.  | 4.  | 61. | 1.000307 | 1.000272 |
| *986.0         | 777.   | 0.1   | -10.3 | 323.  | 13. | 46. | 1.000294 | 1.000284 |
| 978.0          | 991.   | 0.1   | -9.7  | 327.  | 15. | 48. | 1.000292 | 1.000282 |
| *963.0         | 1397.  | -1.4  | -10.5 | 331.  | 19. | 50. | 1.000289 | 1.000279 |
| *947.0         | 1834.  | -2.5  | -12.0 | 330.  | 21. | 48. | 1.000284 | 1.000276 |
| 931.0          | 2277.  | -3.5  | -12.0 | 327.  | 21. | 52. | 1.000280 | 1.000272 |
| 926.0          | 2982.  | -4.2  | -47.6 | 317.  | 21. | 2.  | 1.000262 | 1.000266 |
| 898.0          | 3212.  | -2.5  | -51.5 | 313.  | 20. | 1.  | 1.000258 | 1.000262 |
| *884.0         | 3621.  | -2.8  | -51.7 | 304.  | 20. | 1.  | 1.000254 | 1.000258 |
| 880.0          | 3739.  | -2.6  | -51.6 | 302.  | 20. | 1.  | 1.000253 | 1.000257 |
| *869.0         | 4067.  | -1.4  | -50.8 | 296.  | 21. | 1.  | 1.000248 | 1.000252 |
| 855.0          | 4491.  | -1.2  | -50.7 | 288.  | 22. | 1.  | 1.000244 | 1.000248 |
| *835.0         | 5109.  | -2.5  | -51.5 | 283.  | 25. | 1.  | 1.000240 | 1.000243 |
| *824.0         | 5454.  | -2.1  | -51.3 | 280.  | 27. | 1.  | 1.000236 | 1.000240 |
| *810.0         | 5900.  | -2.8  | -30.7 | 281.  | 30. | 9.  | 1.000235 | 1.000236 |
| *803.0         | 6126.  | -2.8  | -31.5 | 281.  | 31. | 9.  | 1.000233 | 1.000234 |
| 797.0          | 6321.  | -2.6  | -51.6 | 282.  | 33. | 1.  | 1.000229 | 1.000232 |
| *796.0         | 6354.  | -2.6  | -24.7 | 282.  | 33. | 16. | 1.000233 | 1.000232 |
| *789.0         | 6584.  | -2.5  | -11.5 | 282.  | 35. | 50. | 1.000239 | 1.000230 |
| 783.0          | 6782.  | -2.4  | -10.6 | 282.  | 36. | 53. | 1.000238 | 1.000228 |
| *754.0         | 7164.  | -3.8  | -10.9 | 280.  | 41. | 57. | 1.000231 | 1.000220 |
| *742.0         | 8179.  | -4.5  | -11.1 | 279.  | 41. | 60. | 1.000228 | 1.000217 |
| *722.0         | 8886.  | -4.9  | -11.2 | 275.  | 41. | 61. | 1.000222 | 1.000212 |
| 715.0          | 9137.  | -4.6  | -11.0 | 274.  | 41. | 61. | 1.000220 | 1.000210 |
| *692.0         | 9979.  | -6.8  | -13.6 | 271.  | 42. | 58. | 1.000213 | 1.000205 |
| *677.0         | 10540. | -8.1  | -14.9 | 269.  | 42. | 58. | 1.000208 | 1.000201 |
| *665.0         | 10996. | -8.3  | -15.8 | 268.  | 43. | 55. | 1.000204 | 1.000198 |
| 653.0          | 11459. | -9.4  | -20.2 | 266.  | 45. | 41. | 1.000199 | 1.000195 |
| *632.0         | 12286. | -10.8 | -25.8 | 261.  | 51. | 28. | 1.000191 | 1.000190 |
| *622.0         | 12688. | -11.0 | -26.6 | 261.  | 51. | 26. | 1.000188 | 1.000187 |
| 605.0          | 13385. | -12.2 | -38.4 | 262.  | 53. | 9.  | 1.000181 | 1.000183 |
| *594.0         | 13845. | -13.1 | -32.9 | 263.  | 54. | 17. | 1.000179 | 1.000180 |
| 553.0          | 15616. | -18.2 | -29.0 | 262.  | 58. | 38. | 1.000171 | 1.000171 |
| *544.0         | 16018. | -18.8 | -31.4 | 260.  | 60. | 32. | 1.000168 | 1.000169 |
| *541.0         | 16153. | -18.9 | -36.2 | 259.  | 61. | 20. | 1.000167 | 1.000168 |
| 526.0          | 16840. | -19.4 | -49.4 | 256.  | 66. | 5.  | 1.000161 | 1.000163 |
| 512.0          | 17499. | -19.0 | -62.0 | 252.  | 70. | 1.  | 1.000156 | 1.000159 |
| 499.0          | 18127. | -18.9 | -62.0 | 248.  | 75. | 1.  | 1.000152 | 1.000155 |

<sup>1</sup> See Table 2 for an explanation of terms and abbreviations used in this table.

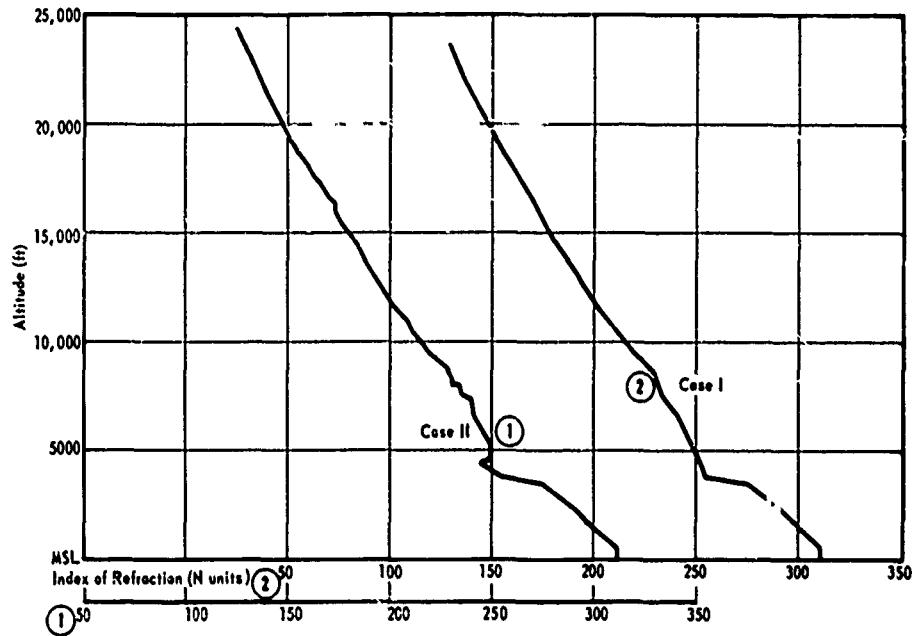


Fig. 10: Comparison of Electrical Index of Refraction Profiles Derived by the Proposed Method and by the 10-Percent Relative Humidity Rule, Eglin Main, 0505Z, 20 February 1963.

TABLE 5. RADIOSONDE DATA AT THE SIGNIFICANT LEVELS,  
EGLIN MAIN, 0505Z, 20 FEBRUARY 1963.

| pl     | G      | T     | D     | THETA | V   | RH  | NE       | NO       | E   |
|--------|--------|-------|-------|-------|-----|-----|----------|----------|-----|
| 1014.3 | 66.    | 5.9   | -0.2  | 340.  | 3.  | 65. | 1.000311 | 1.000286 | 6.7 |
| 998.0  | 502.   | 6.8   | 2.3   | 330.  | 8.  | 73. | 1.000311 | 1.000280 | 7.2 |
| *982.0 | 938.   | 5.9   | 1.5   | 319.  | 3.  | 75. | 1.000306 | 1.000277 | 6.8 |
| *952.0 | 1772.  | 5.3   | 1.0   | 306.  | 18. | 74. | 1.000297 | 1.000269 | 6.6 |
| 938.0  | 2169.  | 5.2   | 0.9   | 303.  | 19. | 74. | 1.000293 | 1.000265 | 6.5 |
| *912.0 | 2925.  | 6.1   | -0.4  | 300.  | 20. | 63. | 1.000282 | 1.000257 | 5.9 |
| *894.0 | 3460.  | 5.2   | -2.2  | 301.  | 20. | 59. | 1.000274 | 1.000253 | 5.2 |
| 885.0  | 3731.  | 4.9   | -17.9 | 301.  | 20. | 17. | 1.000254 | 1.000251 | 1.5 |
| *866.0 | 4313.  | 5.6   | -21.3 | 299.  | 20. | 12. | 1.000246 | 1.000245 | 1.1 |
| 858.0  | 4561.  | 5.2   | -14.2 | 298.  | 21. | 23. | 1.000237 | 1.000243 | 2.0 |
| *842.0 | 5065.  | 4.7   | -8.8  | 295.  | 21. | 37. | 1.000250 | 1.000239 | 3.1 |
| 798.0  | 6490.  | 0.4   | -9.0  | 284.  | 25. | 49. | 1.000242 | 1.000230 | 3.1 |
| *775.0 | 7258.  | -1.3  | -7.4  | 283.  | 27. | 63. | 1.000239 | 1.000224 | 3.5 |
| *769.0 | 7461.  | -1.9  | -3.0  | 282.  | 27. | 63. | 1.000237 | 1.000223 | 3.4 |
| 756.0  | 7926.  | -3.2  | -8.9  | 280.  | 28. | 64. | 1.000233 | 1.000220 | 3.1 |
| 750.0  | 8113.  | -3.6  | -9.3  | 278.  | 28. | 64. | 1.000231 | 1.000219 | 3.0 |
| 736.0  | 8601.  | -4.7  | -8.0  | 277.  | 30. | 78. | 1.000230 | 1.000216 | 3.4 |
| *733.0 | 8706.  | -5.8  | -9.2  | 277.  | 30. | 77. | 1.000229 | 1.000216 | 3.1 |
| 712.0  | 9454.  | -6.2  | -11.9 | 273.  | 34. | 64. | 1.000220 | 1.000210 | 2.5 |
| *695.0 | 10073. | -7.5  | -13.1 | 266.  | 39. | 64. | 1.000215 | 1.000206 | 2.2 |
| *684.0 | 10481. | -8.3  | -14.0 | 267.  | 41. | 63. | 1.000211 | 1.000203 | 2.1 |
| *672.0 | 10931. | -8.8  | -14.4 | 267.  | 44. | 64. | 1.000203 | 1.000200 | 2.0 |
| 653.0  | 11630. | -10.7 | -16.3 | 263.  | 46. | 64. | 1.000202 | 1.000196 | 1.7 |
| 628.0  | 12640. | -13.0 | -18.4 | 263.  | 44. | 63. | 1.000195 | 1.000190 | 1.4 |
| 615.0  | 13163. | -13.7 | -17.6 | 260.  | 45. | 72. | 1.000192 | 1.000187 | 1.5 |
| *598.0 | 13863. | -14.0 | -17.8 | 258.  | 48. | 73. | 1.000187 | 1.000182 | 1.5 |
| *586.0 | 14368. | -14.3 | -19.1 | 258.  | 52. | 67. | 1.000183 | 1.000178 | 1.3 |
| *584.0 | 14453. | -14.7 | -20.1 | 258.  | 52. | 63. | 1.000182 | 1.000178 | 1.2 |
| 568.0  | 15142. | -16.1 | -20.2 | 256.  | 57. | 71. | 1.000178 | 1.000174 | 1.2 |
| *564.0 | 15317. | -16.4 | -20.5 | 256.  | 58. | 71. | 1.000177 | 1.000173 | 1.2 |
| *547.0 | 16071. | -17.7 | -20.3 | 253.  | 61. | 80. | 1.000173 | 1.000169 | 1.2 |
| *543.0 | 16251. | -18.1 | -19.3 | 252.  | 61. | 91. | 1.000173 | 1.000168 | 1.3 |
| 534.0  | 16661. | -18.8 | -20.0 | 250.  | 63. | 90. | 1.000170 | 1.000165 | 1.2 |
| 519.0  | 17357. | -19.8 | -21.9 | 246.  | 64. | 84. | 1.000165 | 1.000161 | 1.1 |
| 515.0  | 17545. | -20.3 | -23.6 | 244.  | 65. | 75. | 1.000163 | 1.000160 | 0.9 |

<sup>1</sup> E is the vapor pressure in millibars. See Table 2 for an explanation of the other terms and abbreviations used in this table.

Fig. 8 even more clearly demonstrates how the addition of more observation points brings out detail that is ordinarily smoothed over. Attention is invited to the section of the profile of Case I between 2600 and 5500 ft. There is no evidence of a deviation of N from a normal gradient. However, in Case II there are definite index changes between 3500 and 5000 ft. This same phenomenon occurs again between 10,000 and 12,500 ft. The addition of observation points also gives a sharper gradient to the negative layer at 6500 ft. This layer had a  $\frac{\Delta N}{\Delta h}$  value of -67 N units per 1000 ft in Case II as contrasted with a value of -42 N units per 1000 ft in Case I.

#### SECTION 4 - CONCLUSIONS

1. A good profile of N can be constructed from the radiosonde soundings, and regular soundings should be useful in studying formations and behavior of ducting or other significant layers of electrical refractive indexes. For many purposes, notably determination of gross radar refractive error, radiosonde in its present form will provide highly useful data.

2. Greater detail in N profiles constructed from radiosonde soundings may be obtained by amending Circular P to permit evaluation of points significant to the N profile.

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2. Manual of Radiosonde Code (Circular P). U. S. Dept of Commerce, Weather Bureau - U. S. Dept of Air Force, Air Weather Service, - U. S. Dept of Navy, Naval Weather Service.

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